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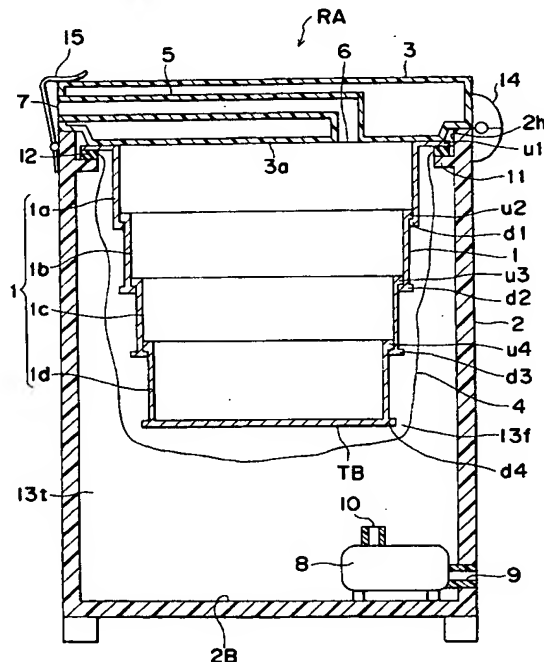
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(54) Refuse compression apparatus.

(57) A refuse compression apparatus (RA) for reducing the volume of a thermal elastic refuse includes a telescopic refuse container (1) which is covered by a bag (4) and is housed in a cylindrical housing (2) as suspended on the top of the cylindrical housing (2). A top cover box (3) is coupled with the telescopic refuse container (1) and the cylindrical housing (2) so that the bag (4) divides the inner space of the cylindrical housing (2) into a free space (13f) inside the bag (4) and an airtight space (13t) outside the bag (4). An air pump (8) provided to connect the airtight space (13t) and the outside of the cylindrical housing (2) operates to pressurize the airtight space (13t), causing that the bag (4) presses the telescopic refuse container (1) to slide up. Thus, the refuse placed in the telescopic refuse container (1) is pressed against the lower surface (3a) of the top cover box (3) and is compressed.

Fig. 1



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## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a refuse compression apparatus for primarily household use for the purpose of reducing the volume of refuse with a low moisture content, such as paper and plastics refuse generated in the home, stores, and offices, by means of a simple operation using a device of simple construction.

### 2. Description of the Prior Art

For example, if cans, bottles, newspapers, and other recyclable refuse is removed from common household refuse, the remaining refuse can be classified in three categories: kitchen garbage such as food wastes, plastic packaging such as for food packaging, and miscellaneous non-recyclable paper. Kitchen garbage represents a very small percent of this total waste volume, and plastics and paper refuse are generally considered to account for over 90% of the total volume.

These wastes are typically processed centrally, collecting refuse by sending garbage collection trucks around on a predetermined schedule to collect the trash, and then haul it to a central processing facility for incineration or burial. It follows that each household must store this refuse in the home until the scheduled collection date, and must deliver the refuse to the scheduled pick-up place by the scheduled time.

Various devices and methods have been proposed to enable on-site (or nearby) processing of these wastes as a means of eliminating the inconveniences of following a fixed schedule. Once such method is the garbage disposal machine, which grinds kitchen wastes into particles small enough to wash down the drain with a flow of water. Other methods include thermal combustion methods using a heater, freezing methods to prevent unpleasant odors, and microwave heating combustion methods. Each of these methods is intended for raw kitchen garbage, however, and cannot be easily adapted for reducing the volume of plastics and paper refuse from the home.

In addition, individual garbage disposal machines used in the home mechanically reduce wastes to be flushed down the drain. This greatly increases the solid and organic waste load in household waste water, increasing the pollution of rivers and lakes with all incumbent social side effects. The tendency today, therefore, is to prohibit the use of such garbage disposal machines the world.

As a result, the most common method of processing garbage is to transfer it to the final waste

processing plant, whether incineration plant, landfill, or other, by garbage collection truck. The waste transportation efficiency of these trucks is increased by compressing the trash in the truck as it is collected, but plastic wastes, including packaging and containers, are voluminous, increasing transportation costs and greatly increasing the necessary landfill area. While demand for recycling plastics has become strong in recent years, recycling costs must be reduced.

Various methods have been introduced for reducing the total volume of plastic wastes at the point of use as one means of reducing the collection cost, one of the biggest parts of the total recycling cost. These methods include both cutting and compression methods. Unfortunately, while both methods are fast, cutting results in minimal volume reduction for wastes other than containers, and available compression methods do not significantly reduce the volume and allow the compressed refuse to expand again unless it is first tied. Methods of waste reduction by heating are therefore more promising than cutting and simple compression because the total volume reduction rate is greatest, particularly with such plastics as polystyrene foam, and the potential economic benefits are therefore also greatest.

In these heating method refuse compression apparatuses, however, heat transfer to the center of polystyrene foam blocks and polyethylene plastics such as those used in trash bags is poor. These wastes must therefore be heated for a long period of time before all of the plastic is softened. Furthermore, if the heating temperature is raised to speed the softening process but is raised too much, the plastic wastes will begin to smoke, giving off foul odors, chloride compounds, and potentially toxic or harmful gases. High speed processing is therefore difficult, and yet low temperature processing results in the entire processing machine becoming soiled and difficult to clean.

### SUMMARY OF THE INVENTION

The object of the present invention is therefore to provide a refuse compression device which solves these problems.

The present invention has been developed with a view to substantially solving the above described disadvantages and has for its essential object to provide an improved refuse compression device.

In order to achieve the aforementioned objective, a refuse compression apparatus for reducing the volume of a refuse, comprises a cylindrical housing having an opening at one end thereof with an opening edge formed therearound; a bag suspended inside the cylindrical housing with the open end thereof held at the opening edge, the bag

dividing the inside space of the cylindrical housing into a first space inside the bag and a second space outside the bag; a volume changeable container having an outer rim for receiving a refuse therein, the expandable container being suspended inside the bag with the outer rim held at the opening edge; a top cover means for closing the opening to seal the opening of the cylindrical housing, the open end of the bag, and the outer rim of volume changeable container; and a pressure increasing means for increasing the air pressure inside the second space.

### BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings throughout which like parts are designated by like reference numerals, and in which:

Fig. 1 is a cross sectional view of a refuse compression apparatus according to a first embodiment of the present invention,

Fig. 2 is a view similar to Fig. 1, but particularly showing a bellows type refuse container according to a modification of the first embodiment of the present invention;

Fig. 3 is a view similar to Fig. 2, but particularly showing an inner plate type refuse container according to another modification of the first embodiment of the present invention,

Fig. 4 is a cross sectional view of a refuse compression apparatus according to a second embodiment of the present invention,

Fig. 5 is a view similar to Fig. 4, but particularly showing an additional hot air generation unit according to a modification of the second embodiment of the present invention,

Fig. 6 is a block diagram showing the constitution of a control unit incorporated in the refuse compression apparatus shown in Fig. 5; and

Fig. 7 is a view similar to Fig. 5, but particularly showing an additional exhausting unit according to another modification of the second embodiment of the present invention.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

#### First Embodiment

Referring to Fig. 1, a refuse compression apparatus according to a first embodiment of the present invention is shown. The refuse compression apparatus RA includes a main housing 2

configuration having a circumferential side wall and a bottom plate 2b. The opposed side of the bottom plate 2b is opened at 2h. The refuse compression apparatus RA further includes a lid 3 also formed in a flat cylindrical box-like configuration having a diameter large enough to cover the opening 2h of the main housing 2. On one of flat sides of the lid 3, a circular tier 3a having a diameter slightly smaller than that of the opening 2h is provided so as to fit it in the opening 2h. An air exhaust pass 5 is formed in the lid 3 such that one end of the pass 5 opens at the circular tier 3a to form an exhaust air inlet 6 and at the other end opens at the side surface of the lid 3 to form an exhaust outlet 7.

A hinge 14 and a clamp 15 are provided on the circumferential side walls of the main housing 2 and lid 3, respectively, so as to oppose to each other so that the lid 3 can swing with respect to the hinge 14 to close or open the opening 2h and can be firmly held at the closed position by the clamp 15.

On the inside surface of the main housing 2, a circular base 11 radially projecting inside by a predetermined length is extending therearound to form an inside rim in a position substantially parallel and proximal to the opening 2h.

A ring packing 12 is placed on the upper surface of circular base 11. A bag 4 made from a soft plastic material, or any other soft material such as rubber, is integrally connected with the ring packing 12 at the inside surface thereof, as shown.

A telescopic refuse container 1 is provided inside the bag 4. The telescopic container 1 includes a top, a first middle, a second middle, and a bottom sub containers 1a, 1b, 1c, and 1d which are formed in a tube-like configuration having rimmed portions at both ends. The top sub container 1a has a diameter larger than those of other sub containers 1b, 1c, and 1d, but smaller than that of the opening 2h. The upper sub container 1a has a first upper flange u1 which extends radially outward and seats on the ring packing 12. The upper sub container 1a also has a first lower flange d1 which extends radially inside by a small amount.

Inside the top sub container 1a, the first middle sub containers 1b which has a second upper flange u2 radially extending outward by a predetermined length almost same as that of the first lower flange d1 and a second lower flange d2 extending inner and outward in a radial direction by a small amount to form a second lower flange d2 is placed.

Similarly, inside the first and second middle sub containers 1b and 1c, the second middle sub container 1c having a third upper and lower flanges u3 and d3 and the bottom sub container 1d having a fourth upper and lower flanges u4 and d4 are placed, respectively. The bottom sub container 1d has a flat bottom TB integrally connected to the

fourth lower flange d4 to completely cover the opening thereat.

These sub containers 1a, 1b, 1c, and 1d joint into each other such that the first, second, and third lower flange d1, d2, and d3 engage with the second, third, and fourth upper flange u2, u3, and u4, respectively, and the second upper flange u2 in a telescopic manner. Thus, the telescopic refuse container 1 can vary the internal volume and is housed within the main housing 2 such that the top sub container 1a rested on the circular base 11 with the ring packing 12 placed between the first upper flange u1 and the circular base 11 to create an airtight seal. Since the telescopic refuse container 1 surrounded by the bag 4 are pressed against the outer circumference of the circular tier 3a when the lid 3 is held at the closed position by the clamped 15, a space inside the main housing 2 is divided into two portions: an airtight space 13t confined by the bag 4 and the main housing 2 in an airtight manner; and a free space 13f confined by the bag 4 and the lid 3.

Inside the main housing 2, an air pump 8 is placed on the bottom plate 2b with an intake port 9 opened at the side wall of the main housing 2 and an outlet port 10 opened to the airtight space 13t. A compression mechanism is thus formed by the telescopic refuse container 1, airtight space 13t formed by the main housing 2, bag 4, circular base 11, and ring packing 12, and the air pressure generated by the air pump 8. It is to be noted that the air pump 8 can be placed outside the housing, or in a compartment provided separately from the airtight space 13t.

In operation, plastic, paper, and similar refuse is placed in the telescopic refuse container 1 and the cover 3 is closed and held at the position firmly. The air pump 8 is then operated to take air into the airtight space 13t through the intake port 9 and the outlet port 10, causing the internal pressure of the airtight space 13t to increase while the internal pressure of the free space 13f remains. This increased internal pressure of the airtight space 13t acts on the bag 4 so that the bag 4 presses each of sub containers 1a, 1b, 1c, and 1d to slide up.

First, the bag 4 pushes up the flat bottom TB of the bottom sub container 1d until the fourth low flange d4 contacts with the third lower flange d3 of the second middle sub container 1c. As the pressure rises continuously, the bag 4 further moves up the second middle sub container 1c such that the fourth lower flange d4 pushes up the third lower flange d3. Thus, the sub containers 1d, 1c, 1b, and 1a slide up toward the lid 3 subsequently and the refuse container 1 reduces the volume. The refuse placed in the refuse container 1 is therefore compressed between the bottom plate TB and the

raised tier 3a, resulting in the volume reduction of the refuse. As the telescopic refuse container 1 shrinks in a telescopic motion, the air inside the free space 13f passes through the exhaust inlet 6 and pass 5 and is vented outside through the exhaust outlet 7.

The volume of refuse can thus be reduced with an extremely simple operation. If a low compression pressure setting is used, a high pressure fan can be used in place of the air pump. If the compression pressure is set at 0.2 kg/cm<sup>2</sup>, and the bottom TB area of the refuse container 1d is approximately 300 cm<sup>2</sup>, a high compressive force of approximately 60 kg is obtained. The main housing 2, lid 3, and refuse container 1 are constructed with sufficient mechanical strength to withstand the forces applied to the respective parts thereof.

The pressure setting can also be set higher, and a compressive force approximately 20 times greater can be easily generated using an air pump. Even higher pressures can be generated using an air compressor. The design pressure level of the refuse compression apparatus can thus be set through a wide pressure range, but the compressive forces described above are sufficient for common household refuse. Furthermore, these pressure levels are more desirable in a refuse compression apparatus for primarily household use due to safety considerations and the ability to construct the apparatus more inexpensively because a special pressure-resistant construction is not required.

In addition, if the air pump 8 is reversed after refuse compacting is completed to depressurise the airtight space 13t, the each of sub container 1a, 1b, 1c, and 1d slides down gravitationally and the refuse container 1 will again expand, creating space to hold additional refuse.

It is to be noted that cylindrically shaped members made of metal are used for the telescopic refuse container 1 in the preferred embodiment described above, but any other shape and material having constructional strength enough to withstand the pressure during the refuse compression operation can be employed.

Referring to Fig. 2, a modification of refuse compression apparatus according to the first embodiment is shown. In this modification, the refuse compression device RB has a construction very similar to that of the first embodiment but includes a cornice refuse container 21 instead of the telescopic type refuse container 1. The cornice refuse container 21 is formed in a single unit having a bellows-like compressible/expandable construction with a variable internal volume. The cornice refuse container 21 formed in a corrugated tubular bag including a flange 21R having a length longer than that of the circular base 11 and a corrugated bellows portion 21B and a circular bottom plate CB

which are integrally formed to configure a container unit. The cornice refuse container 21 is made of a resilient and gas-impermeable material such as plastic but may also be made of a rubber, metal, or other material. A single ring package 32 which is the same as the ring package 12 but is not connecting with the bag 4 in the first embodiment is employed.

As the cornice refuse container 21 is housed within the main housing 2 in the same manner as described above, a space inside the main housing 2 is divided into a airtight space 35t and a free space 35f, by the cornice refuse container 21.

Furthermore, The refuse compression apparatus RB further includes a base 33 provided on the bottom of main housing 2 to cover the air pump 8 and a pair of contractile bellows 34 connecting with the bottom plate CB of the cornice refuse container 21 and the top surface of base 33 for pulling down the bottom plate CB so as to expand the refuse container 21. The contractile bellows 34 is made of a plastic material on the base 33, but it may also be made of a rubber or metal material.

In operation, as the air pump 8 is operated, the internal pressure of the tight space 35t becomes greater than that of the free space 35f as described above. The internal pressure of the free space 35f acts on the bottom plate CB to move up against the pulling force applied by the contractile bellows 34 and to contact with the circular tier 3a of the lid 3. Thus, the refuse placed in the contractile refuse container 21 is compressed between the circular tier 3a and the bottom plate CB. When the internal pressure of the tight space 35t is depressurized by reversing the pump 9, the contractile bellows 34 pull down the cornice refuse container 21 to expand again.

Referring to Fig. 3, another modification of the refuse compression apparatus according to the first embodiment is shown. In this modification, the refuse compression device RC has a construction similar to that of the refuse compression apparatus RA according to the first embodiment. A main housing 42 includes a bottom plate 42b and a circumferential wall 42s to define an opening 42h at another side to oppose to the bottom plate 42 similarly to the main housing 2 of the first embodiment. However, the main housing 42 does not include a circular rim such as the circular base 11 near the opening 42h end but includes a lower rim 51 which extends around the inner surface thereof with a predetermined thickness on a position above the pump 8 and approximately parallel and proximal to the bottom plate 42b.

Furthermore, the telescopic refuse container 1 of the first embodiment is replaced by an inner plate 44 formed in a short cylindrical box-like configuration having a bottom plate 44b and a cylin-

drical side wall 44s to open at one side. The inner plate 44 has the approximately same configuration as the inner configuration of the main housing 42 so that the inner plate 44 can directly fits in the main housing 42 as the open side up. The inner plate 44 freely slides up and down inside the main housing such that the side wall 44s is guided by the inner surface of circumferential wall 42s of the main housing 42. By setting the height of the side wall 44s at a suitable length, the inner plate 44 can slide smoothly between the lid 3 and the lower rim 51. The lower rim 51 defines the lowest position at which the inner plate 44 originally stations due to gravity.

In this case, a space inside the main housing 42 is divided into an airtight space 53t and a free space 53f by the inner plate 44. A ring packing 52 is provided between the opening 42h end of the main housing 42 and the lid 3.

In operation, as the air pump 8 is operated, the internal pressure of the tight space 53t becomes greater, causing the inner plate 44 to slide up to compress the refuse placed therein against the circular tier 3a. When the internal pressure of the airtight space 53t is depressurized by reversing the pump 9, the inner plate 44 gravitates to the original position above the lower rim 51.

It is to be noted that the inner plate 44 is provided with a suitable depth, length of the side wall 44s, in this embodiment, but the same function can be achieved by means of a disk or a concave plate with the concavity on the side not in contact with the refuse.

Furthermore, the combinations of refuse containers and compression mechanism that can be used with a refuse compression apparatus according to the present invention shall not be limited to those described herein, and may include, for example, the refuse container 1 or 44 shown in Figs. 1 or 3 with the contractile bellows 34 shown in Fig. 2, or the bellows-shaped refuse container 21 of Fig. 2 with the bag 4 shown in Fig. 1.

In addition, a deodorizer may also be placed at an appropriate position in the exhaust pass 5 to remove any odorous gas components that may develop during refuse storage or compacting.

## Second Embodiment

Referring to Fig. 4, a refuse compression apparatus according to a second embodiment of the present invention is shown. In this embodiment, the refuse compression apparatus RD has a construction very similar to the refuse compression apparatus RA of the first embodiment. A main housing 13 in cylindrical form has an opening 13h and a circular flange 13c radially extending inside at the opening 13h end. A circular frame 60 having a U-

shaped cross section with the outside surface tapered and an outer flange 60f extending by approximately the same length of that of the circular flange 13c is provided.

The circular frame 60 is placed on the main housing 13 with a bag 64 between the outer flange 60f and the circular flange 13c. Under the circular flange 13c, a circular packing 62 is provided to firmly contact with the circular frame 60 in airtight manner. On the top edge of an inner circle 60i of the circular frame 60, a telescopic refuse container 61 formed very similarly to the telescopic refuse container 1 is suspended such that a top sub container 61a rests on the inner circle 60i and is covered by the bag 64 within the main housing 13. The telescopic refuse container 61 further includes a middle sub container 61b having upper and lower flanges Fu2 and Fd2 and a bottom sub containers 61c having upper and lower flanges Fu3 and Fd3. No bottom plate is provided inside the lower flange Fd3 to open a bottom hole TH.

A bottom tray 67 formed in a cylindrical box-like configuration having a diameter greater than that of the bottom hole TH and a length shorter than those of sub containers 61a, 61b, and 61c is placed inside the bottom sub containers 61c as rested on the lower flange Fd3. Thus, the space inside the main housing 13 is divided into a free space 63f and an airtight space 63t.

On the bottom of the main housing 13, an air pump 68 with an intake port 69 opened at the side wall of the main housing 13 and an outlet port 70 opened to the airtight space 63t. A compression unit CU is thus formed by the main housing 13, ring packing 62, bag 64, circular frame 60, telescopic refuse container 61, and bottom tray 67 which is activated by the air pump 68 to increase the inner pressure of the air tight space 63t.

In this embodiment, the refuse compression apparatus RD further includes an exterior housing 43 formed in a rectangular box-like configuration confined by a top plate 43t, a bottom plate 43b, a first side plate 43s, a second side plate (not shown) and a third side plate 43r to have a front opening on the left side, as shown in Fig. 4. Under the top plate 43t, a sub plate 43L is integrally connected with the top plate 43t as to form a lid box LB having a box-like structure. Air exhaust inlets 46 and outlets 47 are provided on the lower surface 43L and side surface of the sub plate 43t, respectively, to make an air pass connecting the free space 63f and the outside the refuse compression apparatus RD.

A lifting mechanism 65 with wheels 66 is provided to move the compression unit CU into and out from the exterior housing through the front opening (shown left in Fig. 4) as the compression unit CU mounted thereon.

In operation, the compression unit CU mounted on the lifting mechanism 65 with wheels 66 is carried into the exterior housing 43 to locate under the sub plate 43L. The compression unit CU is further lift up by the lifting mechanism 65 so that the compression unit CU pressedly contacts with the lower surface of the sub plate 43L in airtight manner as the air exhaust inlet 46 are confined by the telescopic refuse container 61. Similarly to the above described embodiment, as the inner pressure of the airtight space 63t is increased by the pump 68, the bag 64 is pressed against the telescopic refuse container 61, causing each of sub containers 61c, 61b, and 61a to slide up to the upper position defined by the sub plate 43L. When the telescopic refuse container 61 shrinks and reaches the upper position, the bag 64 further press the bottom tray 67 against the sub plate 43L through the bottom hole TH so that the refuse placed in the bottom tray 67 is compressed between the bottom tray 67 and the sub plate 43L. It is to be noted that since the compression unit CU is now firmly held between the sub plate 43L and the bottom plate 43b, the air pressure generated by the air pump 68 is effectively used for compressing the refuse. However, if the exterior housing 43 has a weight enough to withstand such air pressure, the bottom plate 43b can be omitted. As the airtight space 63t expands, the air in the free space 63f is taken out from the refuse compression apparatus through the air exhaust path 46 and 47.

For maximum compression of paper, cans, and other compressible refuse, it is effective to make the height of the bottom tray 67 walls sufficiently low relative to the height of the walls of sub containers 61a, 61b, and 61c. By setting the height of bottom tray 67 at an optimum value as shown in the figure, the compression rate per single operation with this embodiment is a maximum of approximately 1/7, and refuse can be loaded after compacting to repeat the process plural times.

Referring to Fig. 5, a modification of the refuse compression apparatus according to the second embodiment is shown. In this modification, the refuse compression apparatus RE has a construction similar to that of the refuse compression apparatus RD according to the second embodiment. The most significant difference in the construction of this embodiment is the use of a hot air generating unit HU, incorporated in a lid box LB', formed by an electric heater 72 for heating the air, a fan 71 for moving the heated air to make a heated air stream, a temperature sensor 73 for detecting a temperature of the heated air stream and a control unit CL (not shown) for controlling the operation of the refuse compression apparatus RE. In this embodiment, the lower plate of the lid box LB' is formed by a metal, but any other heat resistant

material having a mechanical strength enough to withstand the pressure applied during the refuse compression may be used. It is to be noted that there is a tendency for bad odors to result from heating the plastic refuse because food remainders will typically be left on the plastic refuse. An oxidation catalyst layer is therefore formed on the surface of the electric heater 72 in this modification to provide a deodorization function to clean odor vectors from the circulating hot air so that the released air is odorless.

On the bottom of the lid box LB', a perforated vent 85 for passing the hot air stream is provided on a circular area having a diameter approximately same as that of the refuse container 61. An air intake 86 is further provided on the outer position with respect to the perforated vent 85.

In a compression unit CU' of this modification, a circular frame 78 having a construction very similar to the circular frame 78f but having an air hole 78a opened on the bottom oppose so as to the air intake 86. A bottom tray 79 has the same construction as that of the bottom tray 67 except the bottom tray 79 has air holes 79h provided on the bottom thereof. A flat ring packing 62' is placed between the lid box LB' and the circular frame 78f.

In operation, when the lifting mechanism 65 is operated so that the compression unit CU' is moved up to couple with the hot air generating unit HU. Electricity is then supplied to the electric heater 72 to raise the temperature of the ambient air and to produce a hot air, and the fan 71 is run. The hot air stream is forced through the perforated vent 85 into the refuse container 61, thus heating the plastic refuse contained therein and passing out through the holes 79h and TH from the container 61. The exhausted air passes the air space between the bag 64 and the refuse container 61 and returns the hot air generating means HU through the air holes 78a, and is recirculated to the fan 71 from the air intake 86, thus circulating the hot air inside and outside of the refuse container 61.

Plastic refuse in the refuse container 61 is thus heated to enable more efficient compacting. The temperature of the plastic refuse is controlled by detecting the temperature of the air by means of the temperature detector 73 provided near the perforated vent 85. Plastic refuse can be processed more quickly with a higher heating temperature setting, but the high probability of chloride-containing plastics (e.g., polyvinyl chloride (PVC), polyvinylidene chloride) being processed requires extra care be taken to prevent emission of noxious gases due to thermal decomposition of the plastic. The appropriate temperature is thus 130°C, but the recommended range is 104°C to 140°C. These temperatures are determined in consideration of that the largest component of plastic refuse on a

volume base is polystyrene foam, which is used for fresh food trays. Second is polyvinyl chloride products used in small bottles and in tofu (Soy bean curd) and egg containers, polyvinylidene chloride products used in plastic food wrap and airtight coverings for instant or prepared foods, and other chloride plastic products. We found that there is a rapid drop in the elasticity of polystyrene foam products at air pump 104°C, at which point compacting becomes easier, that thermal decomposition of and hydrogen chloride gas emission by chloride plastics begins at approximately 170°C with PVC products and approximately 130°C with polyvinylidene chloride products, and that the concentration of these gases is high enough (approx. 0.5 ppm) for a pungent odor to be smelled at approximately 140°C. It was thus determined that the appropriate heating range for a plastic refuse processing apparatus intended primarily for home use is from 104°C to 140°C, and the limit range of plastic refuse heating is therefore so specified for the present invention.

When the temperature of the plastic refuse in the refuse container 61 reaches this predetermined temperature range. Air pressure is used for the compression operation of this embodiment because a low pressure setting can generate a high compressive force, and offers relatively greater safety.

When the air pump 68 is started, air from outside the system is taken in through the air intake 69 and pumped through to the airtight space 63t' from the air outlet 69, thus increasing the pressure inside the airtight space 63t'. The bag 64 thus begins to contract, raising the bottom of the bottom tray 79 through the bottom hole TH of the bottom sub container 61c. The refuse container 61 thus contracts and the internal volume decreases, compacting the plastic refuse contained therein.

Because the increase in temperature significantly reduces the elasticity of the plastic, softening or even melting the plastic refuse, it is easily compacted by contraction of the refuse container 61, and the volume of the plastic refuse is significantly reduced. This compression operation can be repeated plural times during the heating process. It is to be noted that heating the plastic will greatly reduce but not eliminate the elasticity of the plastic, and as the pressure is released the remaining elasticity of the plastic can cause it to expand again, greatly reducing the compression rate (height after compression/height before compression). To prevent this it is necessary to cool the plastic before reducing the pressure.

Natural cooling can be used, but the compression time can be reduced by using the fan 71 or a dedicated cooling fan (not shown). By thus cooling the plastic refuse while still pressurized, the refuse



is solidified in the compressed state as compression is completed. After refuse process is completed, the compression unit CU' mounted on the lifting mechanism 65 with wheels 66 can be carried out from the exterior housing 43 for removing the small lump of compacted plastic refuse from the refuse container 61 to throw away.

It is to be noted that the height of compacted refuse is limited by the height of the walls of the bottom tray 79 because the refuse container 61 is composed of three cylindrical sub containers 61a, 61b, and 61c and the bottom tray 79. To increase the compression rate, it is effective to make the height of the bottom tray 79 walls sufficiently low relative to the height of the walls of the sub containers 61a, 61b, and 61c.

Referring to Fig. 6, an example of refuse compression operation by the refuse compression apparatus RE is described. The control unit CL includes the temperature sensor 73 which detects the temperature of the air stream near the perforate vent 85 and produces a temperature signal St based on the detected temperature, the heater 72, the fan 71, the air pump 68, a counter 80 which counts number and produces a count signal Sce indicative of the counted number, and a control circuit 81 for controlling the heater 72, the fan 71, the air pump 68, and the counter 80 according to the temperature signal St and count signal Sce.

First, when the control unit CL is operated to turn the heater 72, the control unit CL produces a fan start signal Sfs for turning on the fan 71 and a heater start signal Shs for turning on the heater 72.

When the detected temperature St reaches the above described predetermined temperature range, the control circuit 81 produces a pump start signal Sps for activating the air pump 68 and a counter start signal Scs for activating the counter 80 to count number or time. It is to be noted that the temperature of air stream is employed for determination of the refuse's temperature because detection of actual temperature of the refuse is not practical.

On receipt of the pump start signal Sps, the air pump 68 takes the air into to the compression unit CU', causing the refuse to be compressed in the above described manner. The control circuit 81 turns ON and OFF the heater 72 according to the temperature signal St so that the detected temperature St is maintained within the predetermined preferable range 104 to 140°C.

When the counter 80 counts up a first predetermined number T1, or a first predetermined period, the control circuit 81 produces a heater stop signal Shq for turning off the heater 72. The first predetermined number T1 is determined in consideration of the required time for the refuse container 61 to slide up and the thermally softened

plastic refuse to be compressed completely. Since the fan 71 is still operating, the air stream not heated is circulated to forcibly cool down the heated plastic refuse on the bottom tray 79 as compressed.

When the counter 80 counts up a second predetermined number T2, the control circuit 81 produces a fan stop signal Sfq for turning off the fan 71 and a pump reverse signal Spr for reversing the air pump 68 to depressurize the inside pressure of the airtight space 63t' for returning the refuse container 61 to the original position. The second predetermined number T2 is determined in consideration of the required time for the heated plastic refuse to cool down to a temperature at which the compressed plastic can not expand again.

When the counter 80 counts up a third predetermined number T3, the control circuit 81 produces a pump stop signal Spq for turning off the air pump 68. The third predetermined number T3 is determined in consideration of the required time for the contracted refuse containers 61a, 61b, and 61c slide down to the original position. It is also possible to set the control circuit 81 to produce the fan stop signal Sfs when the counter 80 counts up the first predetermined number T1 so that the heated plastic refuse will be cooled down naturally.

Since there is no means for exhausting the heated air outward during the refuse compressing operation in this embodiment, the space 63f' inside the bag 64 is also confined by the compression unit CU' and the lid box LB' in airtight manner. However, it is to be noted that the bag 64 can compress the space 63f' due to an imbalance of the inner pressures of the airtight space 63t' and the space 63f', requiring a higher pressure when compared with the above described embodiments.

Referring to Fig. 7, another modification of the refuse compression apparatus RF according to the second embodiment is shown. In this modification, the refuse compression apparatus RF has the almost the same construction as that of the refuse compression apparatus RE shown in Fig. 5 except that the heater 72 is replaced by a heater 72' having no catalyst layer and an exhaust unit 90 including a catalyst for deodorization is additionally provided on the hot air generating unit HU'. The exhaust unit 90 includes an exhaust inlet 92 at a top of the hot air generation heating unit HU' and an exhaust outlet 91 at the side of the lid box LB'' and exhausts the deodorized heated air from the refuse compression apparatus RF during the compressing the refuse. Thus, the refuse compression apparatus RF can compress the plastic refuse with a lower pressure when compared with the refuse compression apparatus RD and prevent a smelly air spreads out.

Furthermore, while the hot air generating unit



HU' in this embodiment is secured to the outside of the compression unit CU', and the compression unit CU' is moved when putting refuse into or removing refuse from the compression unit CU', it is also possible to have the compression unit CU' stationary and the hot air generating unit HU' in the lid box LB'' that is opened and closed.

Furthermore, the refuse compression apparatus according to the present invention is intended primarily as a plastic refuse processing system for private residential use, but its application shall not be so limited and the refuse compression apparatus can be used with equal effectiveness to reduce the volume of plastic refuse in stores, offices, small-scale business operations, and similar sites.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

## Claims

1. A refuse compression apparatus (RA) for reducing the volume of a refuse, comprising:

a cylindrical housing (2) having an opening (2h) at one end thereof with an opening edge formed therearound;

a bag (4) suspended inside said cylindrical housing (2) with the open end thereof held at said opening edge, said bag (4) dividing the inside space of said cylindrical housing (2) into a first space (13f) inside said bag (4) and a second space (13t) outside said bag (4);

a volume changeable container (1) having an outer rim (u1) for receiving a refuse therein, said expandable container (1) being suspended inside said bag (4) with the said outer rim (u1) held at said opening edge;

a top cover means (3) for closing said opening (2h) to seal said opening (2h) of said cylindrical housing (2), said open end of said bag (4), and said outer rim (u1) of said volume changeable container (1); and

a pressure increasing means (8) for increasing the air pressure inside said second space (13t).

2. A refuse compression apparatus (RA) as claimed in Claim 1, wherein said volume changeable container (2) comprises:

a top sub container (1a) including a tubular body which has a first upper and a first lower open ends and a first predetermined diameter,

said top sub container having a first upper rim (u1) radially projecting outward from said first upper open end by a first predetermined length enough to overlap said opening (2h) and a first lower rim (d1) radially projecting inside from said first lower open end by a second predetermined length;

a middle sub container (1b and 1c) including a second tubular body which has a second upper and a second lower open ends and a second predetermined diameter approximately same as said first predetermined diameter minus twice of said second predetermined length, said middle sub container having a second outer rim (u2 and u3) radially projecting outward from said second upper open end by a second predetermined length and a second lower rim (d2 and d3) radially projecting inside by a third predetermined length and outward by a fourth predetermined length approximately same as said second predetermined length from said second lower open end; and

a bottom sub container (1d) including a third tubular body which has a third upper open end and a first bottom plate (TB) provided at the other end to oppose to said third upper open end to close thereof and a third predetermined diameter approximately same as said second predetermined diameter minus twice of said third predetermined length, said bottom sub container (1d) having a third upper rim (u4) radially projecting outward from said third upper open end by a third predetermined length and a third outer rim (d4) by a fourth predetermined length approximately same as said third predetermined length, whereby said top, middle, and bottom sub containers (1a, 1b, 1c, and 1d) slidably fit in another to assembly said volume changeable container (2) such as said first (d1) and second (d2 and d3) inner rims slide between said second upper rim (u2 and u3) and said second lower rim (d2 and d3) and between said third upper rim (u4) and said third lower rim (d4), respectively, and thus the volume thereof can be changed.

3. A refuse compression apparatus (RA) as claimed in Claim 2, further comprising a bottom tray (67) including a fourth tubular body which is shorter than any of said top, middle, and bottom sub containers (1a, 1b, 1c, and 1d) and has a fourth upper open end and a second bottom plate provided at the other end to oppose to said fourth upper open end to close thereof and a fourth predetermined diameter approximately smaller than said third predetermined diameter so that said bottom tray

placed inside said bottom sub container (1d) as said fourth upper open end up can reduce the volume of said refuse placed therein more than the volume reduced by said volume changeable container (1) only.

4. A refuse compression apparatus (RA) as claimed in Claim 1, further comprising a sealing means (12) formed in a ring-like configuration large enough to cover said opening (2h) end and is placed on said opening end (2h) to keep the airtightness between said bag (4) and said cylindrical housing (2) when said top cover means (3) is held at the closed position.

5. A refuse compression apparatus (RA) as claimed in Claim 4, wherein said sealing means (12) is integrally connected with the open end of said bag (4).

6. A refuse compression apparatus (RA) for reducing the volume of a refuse, said apparatus comprising:

a cylindrical housing (2) having an opening (2h);

a circular rim (11) extending the inner surface of said cylindrical housing (2) approximately parallel and proximal to said opening (2h) end;

a sealing means (12) formed in a ring-like configuration so as to cover said circular rim (11), said sealing means (12) being placed on said circular rim (11);

a bag (4) having an open end integrally connected with said sealing means (12) suspended inside said cylindrical housing (2), said bag (4) dividing the inside space of said cylindrical housing (2) into a first space (13f) inside said bag (4) and a second space (13t) outside said bag (4);

an expandable container (1) for receiving a refuse therein sub cylindrical containers (1a, 1b, 1c, and 1d) which join and slide in a telescopic manner, said container being suspended inside said bag (4) with said open end thereof held at said circular rim (11);

a top cover (3) for closing said opening (2h) end to keep the inside space of said cylindrical housing (2) in airtight manner; and

a pressure increasing means (8) for increasing the air pressure inside said second space (13t).

7. A refuse compression apparatus (RB) for reducing the volume of a refuse, said apparatus comprising:

a cylindrical housing (2) having an opening (2h);

a volume changeable container (21) for receiving said refuse having a corrugated tubular portion (21) and a flat bottom (CB) which are integrally formed in a bellows-like cylindrical container having an outer rim (21R) radially projecting outward by a predetermined length, said volume changeable container (21) being suspended inside said cylindrical housing (2) with said outer rim (21R) held at said opening (2h) end so as to divide the inside space of said cylindrical housing (2) into a first space (35f) inside said volume changeable container (21) and a second space (35t) outside said volume changeable container (21);

a top cover means (3) for closing said opening (2h) to keep the airtightness between said opening (2h) end of said cylindrical housing (2) and said outer rim (21R); and

a pressure increasing means (8) for increasing the air pressure inside said second space (35t).

8. A refuse compression apparatus (RC) for reducing the volume of a refuse, said apparatus comprising:

a cylindrical housing (42) having an opening (42h);

a circular rim (51) radially projecting by a predetermined length from the inner surface of said cylindrical housing (2) approximately parallel and proximal to the closed end (42b) of said cylindrical housing (2);

a sliding tray (44) placed between said opening (2h) end and said circular rim (52) for receiving said refuse having a circular configuration approximately same as an inside the cross sectional configuration of said cylindrical housing (52) and a side wall (44S) so that sliding tray (44) vertically slides with said side wall (44S) guided by the inside wall (42s) of said cylindrical housing, said sliding tray (44) dividing the inside space of said cylindrical housing (42) into a first space (53f) between said sliding tray (44) and said opening (2h) end and a second space (13t) between said sliding tray (44) and the closed end of said cylindrical housing (52);

a top cover means (3) for closing said opening (2h) of said cylindrical housing (2),

a pressure increasing means (8) for increasing the air pressure inside said second space (53t); and

an air pump (8) provided inside said cylindrical housing (2) having a first port (9) opened to the outside of said cylindrical housing (42) and a second port (10) opened to said second space (53t) for changing the air pressure of said second space (13t), whereby when said

air pump (8) is operated to increase the air pressure of said second space (13t), said sliding tray (44) moves up and presses said refuse placed therein against said top cover (3) to compress the volume of said refuse.

9. A refuse compression apparatus (RE) as claimed in Claim 1, further comprising:

a hot air stream generation means (HU) provided inside said top cover means (3) for producing a heated air stream, said hot air stream generation means comprising:

an heater means (72) for heating the air to produce a heated air; and

a fan means (71) for moving said heated air to produce a hot air stream;

a plurality of air passes (85) formed in the lower surface of said top cover means (3) for moving said hot air stream between said hot air stream generation means (HU) and said first space (63f); and

a compression control means (CL) comprising:

a temperature detection means (73) for detecting a temperature of said heated to produce a temperature signal (St) representing said detected temperature;

a counter means (80) for counting numbers to produce a counter signal (Sce) representing the elapsed time after said counter means (80) starts; and

a control means (81) for producing a heater signal (Shs) for turning on and off said heater means (72) to maintain said detected temperature within a first predetermined temperature range after the operation starts, a fan start signal (Ssf) for turning on said fan means (71) to make a stream of said heated air, a counter start signal (Scs) for turning on said counter means (80) when said detected temperature reaches said first predetermined temperature range, and a pump start signal (Sps) for tuning on said pressure increasing means (68) to pressurize said second space (63t) when said detected temperature reaches said first predetermined temperature range so that said bag (4) moves up said volume changeable container (1) and presses said refuse heated by said hot air stream against said top cover (3) to compress the volume thereof.

10. A refuse compression apparatus (RE) as claimed in Claim 9, wherein said first predetermined temperature is between 104°C and 140°C.

11. A refuse compression apparatus (RE) as claimed in Claim 9, wherein said control

means (81) further produces a heater stop signal (Shq) for turning off said heater means (72) when said counter means (80) counts up a first predetermined number (T1), and a pump stop signal (Spq) for turning off said pressure increasing means (68) when said counter means (80) counts up a second predetermined number (T2) which is greater than said first predetermined number (T1) so as to cool down said heated refuse as being compressed between said top cover (3) and said volume changeable container (1) until said counter means (80) counts up said second predetermined number (T2).

12. A refuse compression apparatus (RE) as claimed in Claim 9, wherein said control means (81) further produces a pump reverse signal (Spr) for reversing said pressure increasing means (68) when said counter means (80) counts up a third predetermined number (T3) greater than said second number (T2) so that said volume changeable container (61) returns to the original position for next process after said compressed refuse cools down.

13. A refuse compression apparatus (RE) as claimed in Claim 9, wherein said heater means (72) comprises a catalyst provided on a surface thereof for deodorization of said hot air stream.

Fig. 1

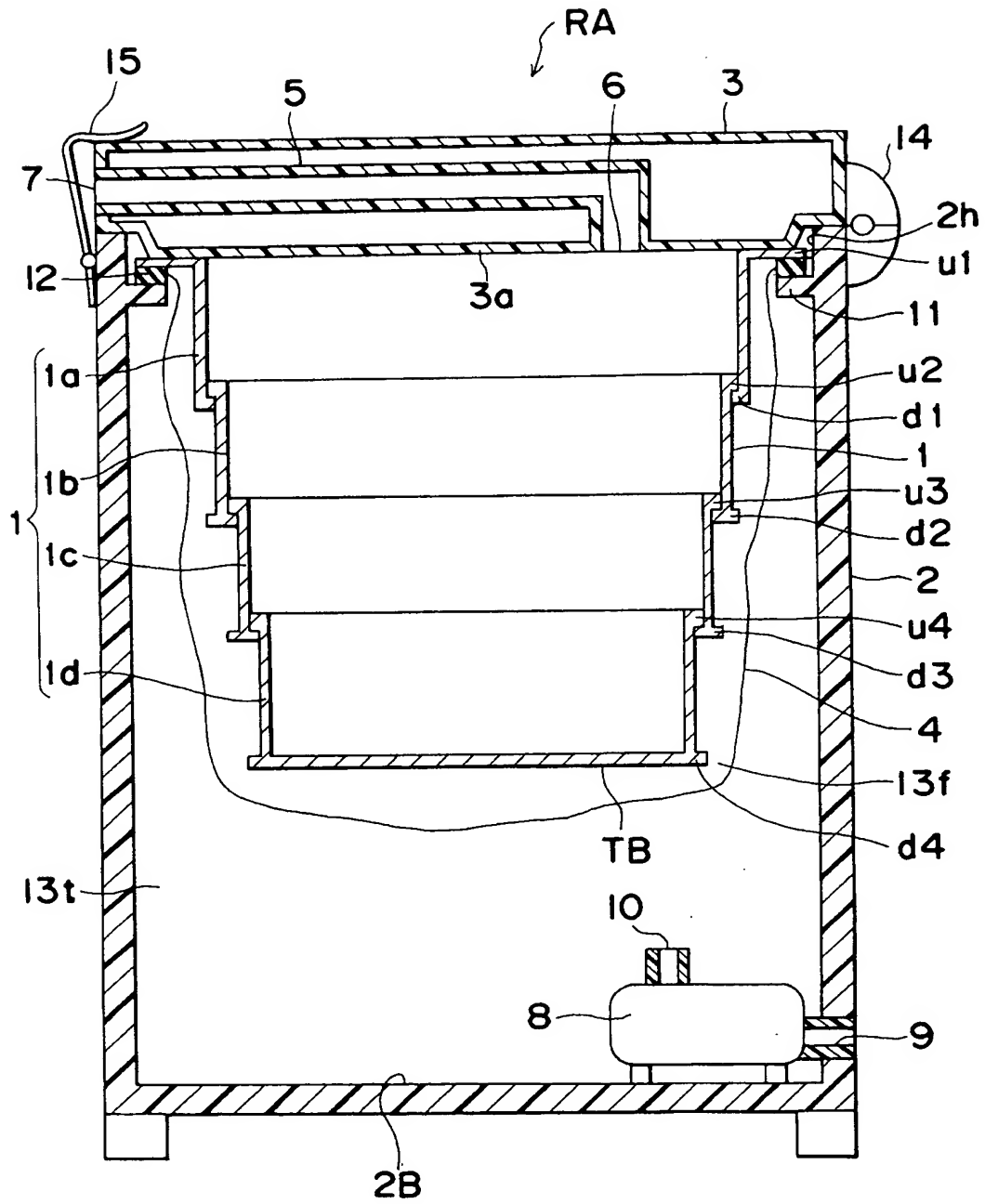


Fig. 2

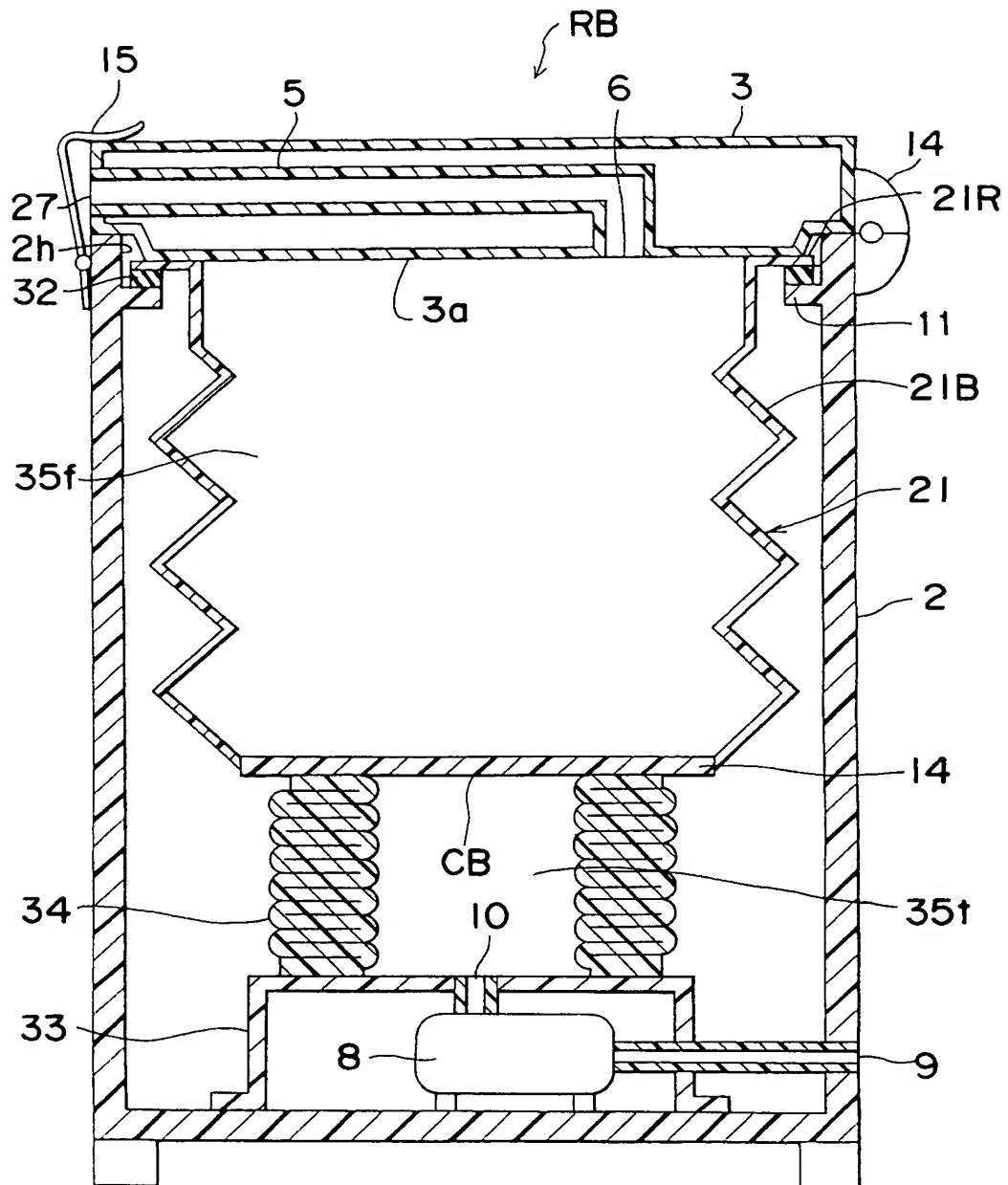
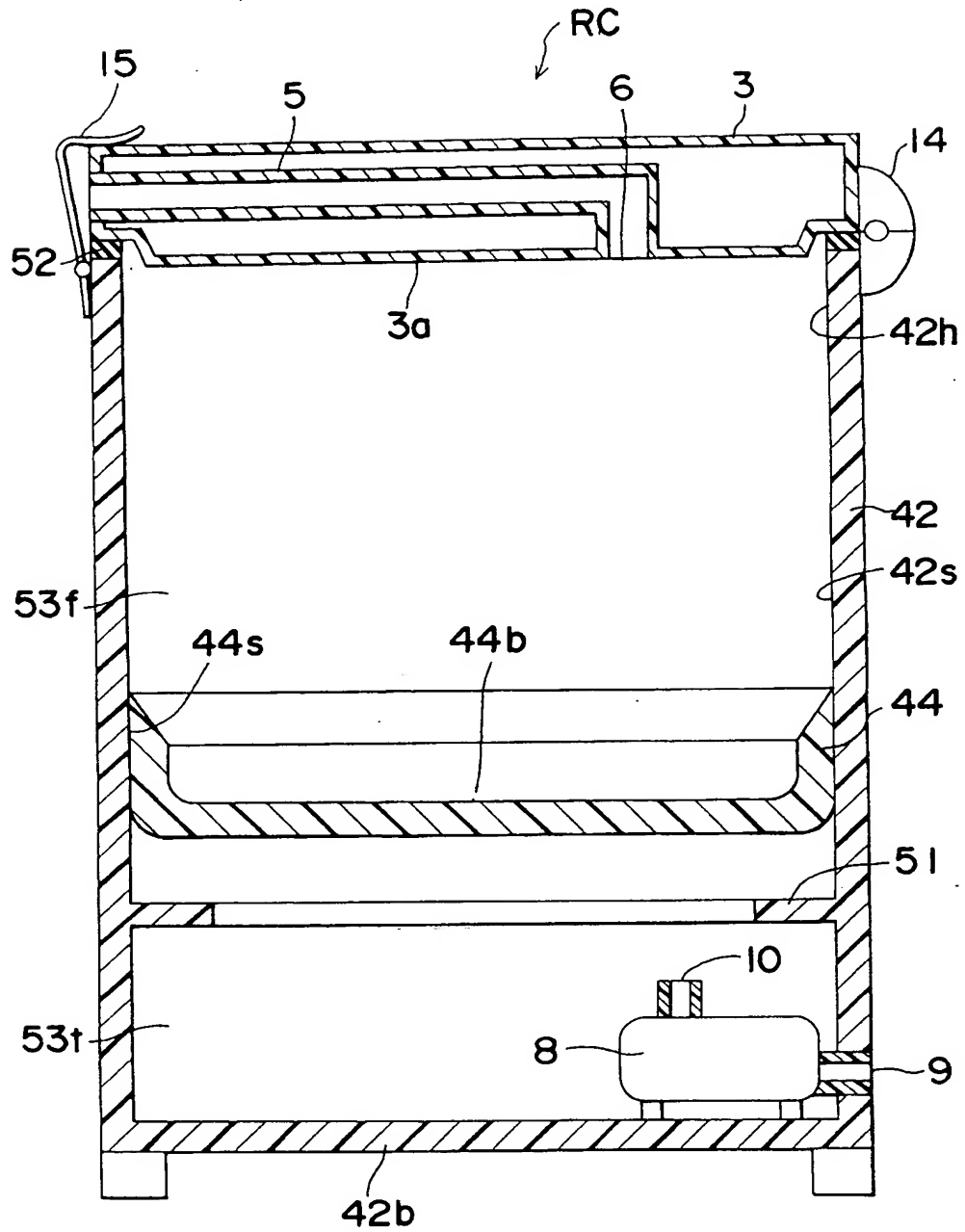


Fig. 3



*Fig. 4*

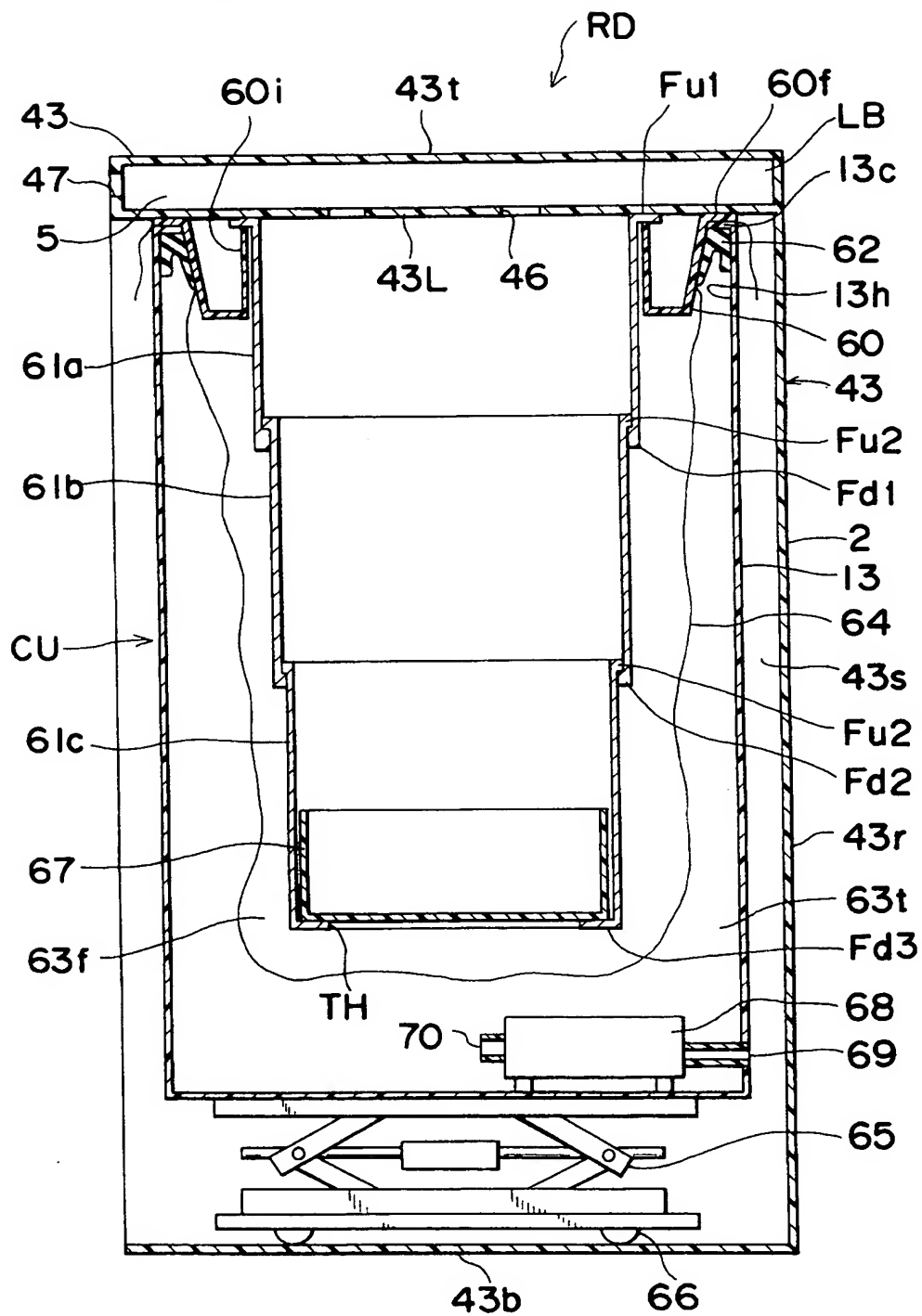




Fig. 5

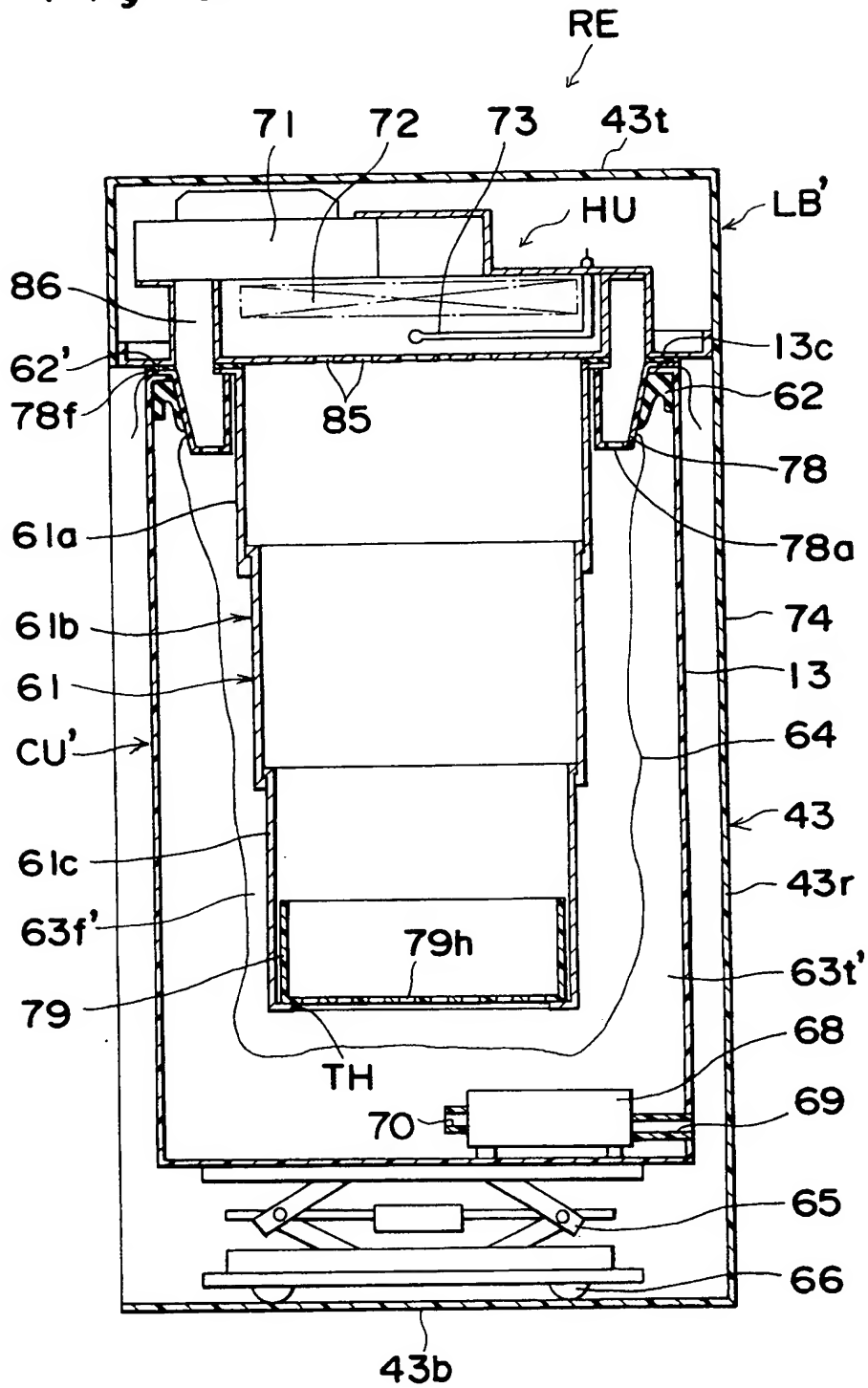


Fig. 6

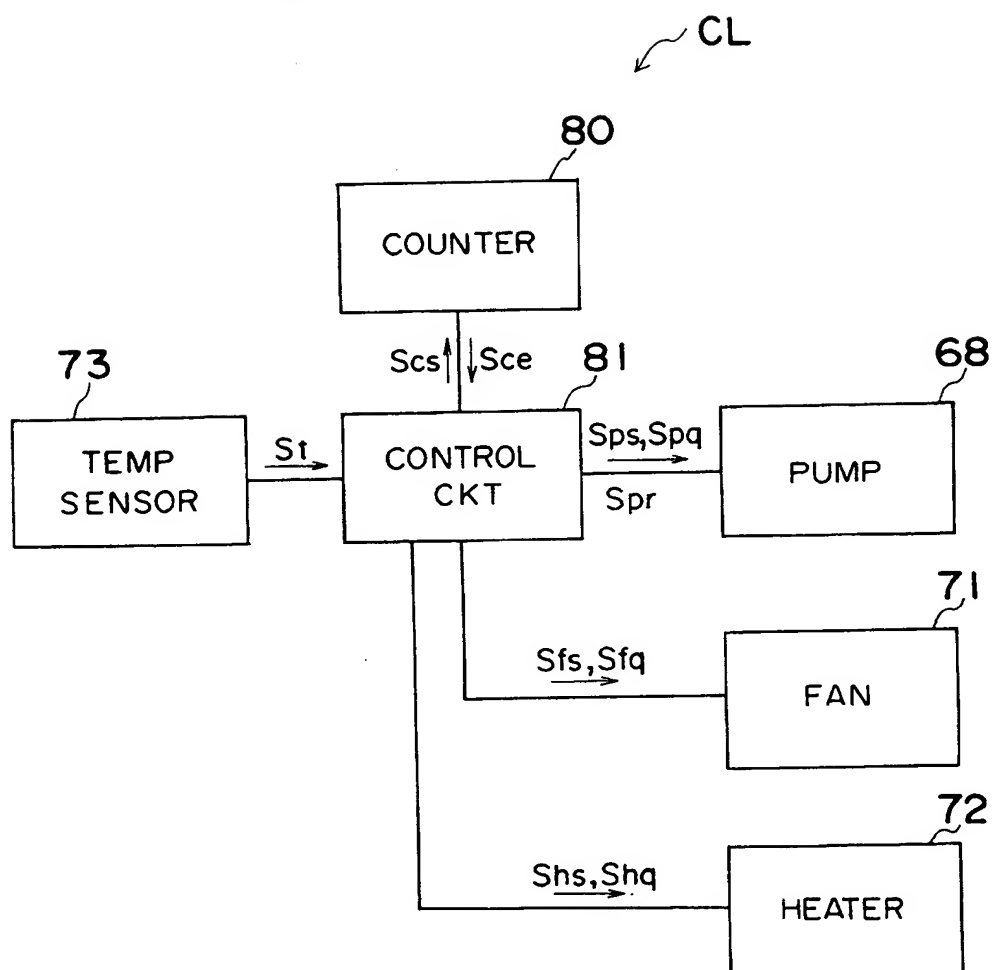
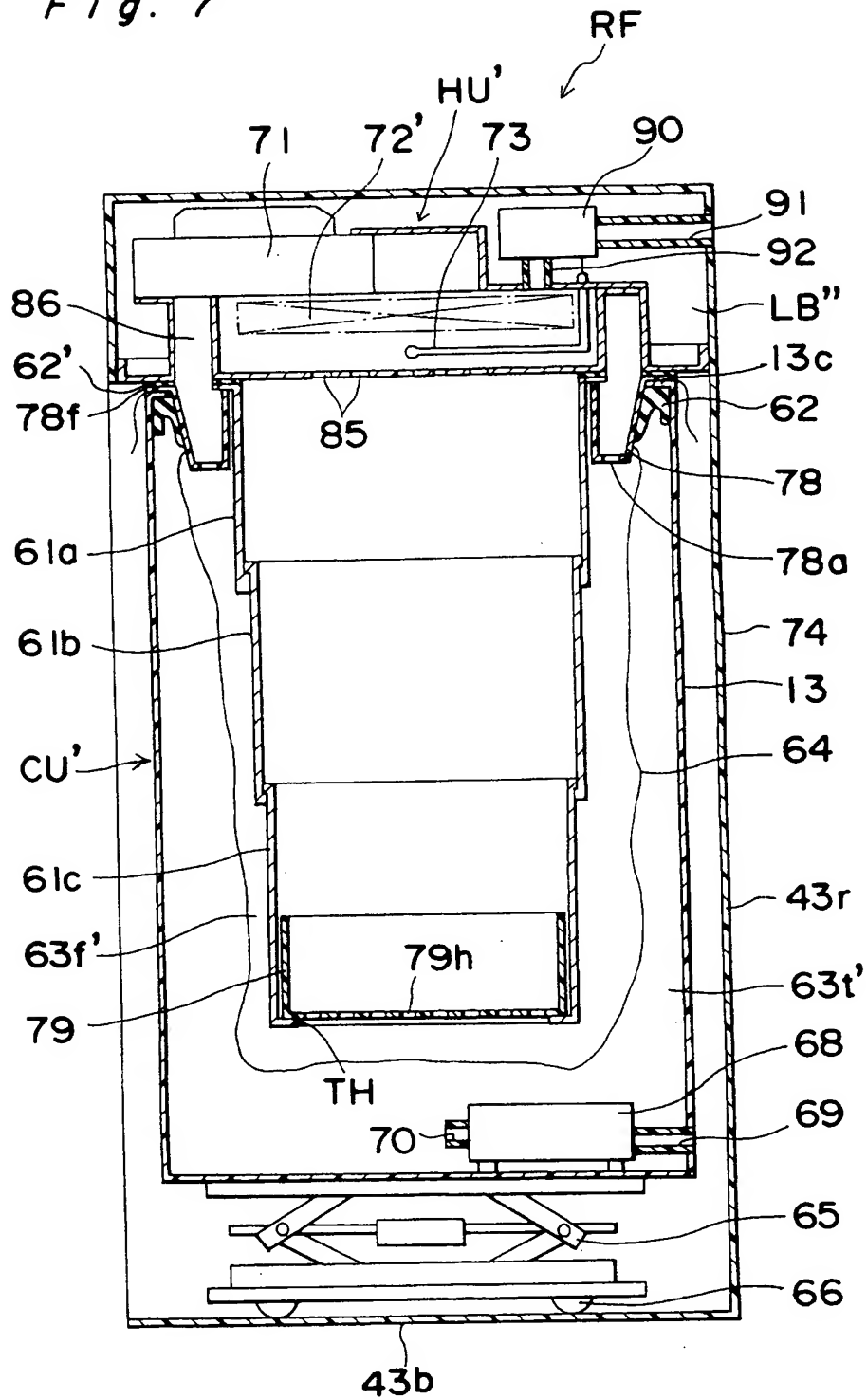


Fig. 7



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